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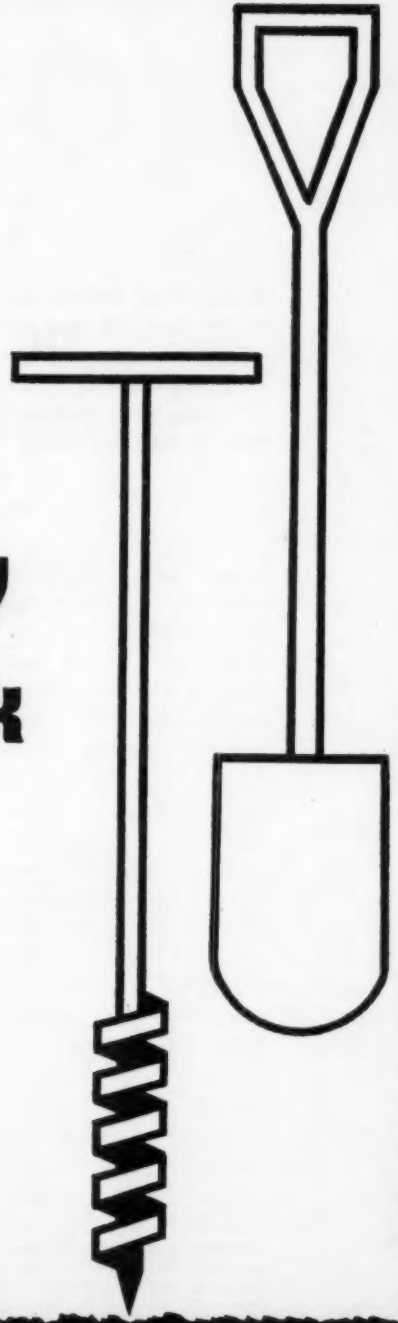
A Study of Soil Fertility on New York Farms



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A Study of Soil Fertility on New York Farms

D. J. Lathwell and T. W. Scott

There are many ways to evaluate the fertility status of soils and the amounts of additional lime and fertilizer necessary for optimum crop production. The accepted standard for determining the fertility status of soils is the field experiment, which uses various fertility additions. From the field experiment, optimum kinds and amounts of fertility additions can be determined, and general fertilizer and lime recommendations can be made. The high cost and limited physical resources available preclude the possibility of conducting field experiments on every soil type and under every climatic condition.

One way to obviate the difficulty of conducting the necessary number of field experiments is to study the relationship between the fertility status of soils as determined by chemical soil tests and crop response to fertility additions on representative soils. If a good relationship can be established between chemical soil tests and crop response, the problem of evaluating the fertility status of the soils on a given farm or field becomes relatively simple. Soil samples can be taken from many fields and the chemical analyses performed in a relatively short time and at reasonable cost. Sufficient field and green house experimentation has been done to show that chemical soil tests indicate the fertility status of soils with reasonable accuracy.

The Department of Agronomy has offered a soil testing service to the farmers of New York State for a number of years, and substantial numbers of them have taken advantage of the service. This bulletin is concerned with the fertility status of New York soils as revealed by chemical soil tests on samples submitted to the soil testing laboratory during the years 1957 and 1958. It is also concerned with the lime and fertilizer practices used by New York farmers as reported on information sheets accompanying each soil sample.

Source of Soil Samples and Information Obtained

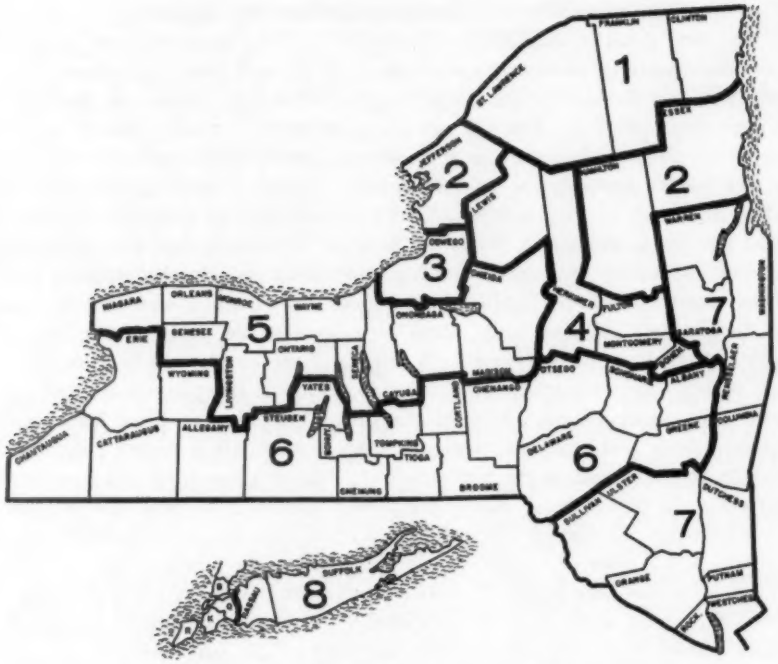
Nearly 53,000 soil samples were received from all the agricultural counties of New York State during 1957 and 1958. Although the majority of the samples received were from dairy farms, all of the major cropping systems are represented. Results obtained solely from fruit farms are not included in this study. Cropping systems or rotations included were dairy (corn, oats, hay), small grain, hay, cash grain, vegetable crops, plowable pasture, permanent pasture, and continuous hay. Chemical soil tests were made on all samples submitted to the laboratory and included determination of soil pH, available phosphorus and potassium, and organic-matter content.

The results of the chemical soil tests made on each sample were tabulated. In addition, information was tabulated concerning the past history of the field from which the sample came, including the last crop grown and the fertility practices used on that crop. From this information it was possible to determine and compare the fertility status of soils from various regions of the State produced under different cropping systems. It was also possible to determine the fertility practices used on different crops by farmers throughout the State. This information was analyzed to provide the information presented in the following discussions.

Fertility Status of New York Soils

The data in the tables that follow are presented to show the percentage of samples that fall in either a low or high category. The percentage in the intermediate range can be calculated by adding together the percentage of samples in the low and high categories and subtracting from 100. The soil was considered low in pH if it was below 6.0 and high if above 6.5. For soil phosphorus, the low range was 0 to 3 pounds per acre; the high range included all samples with soil test values 8 pounds per acre and above. The low range of soil potassium was 0 to 80 pounds per acre and the high range included all samples above 150 pounds per acre. The results of field experiments have indicated that response to lime, phosphorus, and potassium can be expected when the levels fall in the low range. On the other hand, little or no response to additions of these elements can be expected when the soil test values are high.

Using the above criteria to indicate the need for lime, two-fifths of all the samples showed a need for additional lime for most crops, the notable exception being potatoes. Only slightly more than one-quarter of the samples analyzed had a soil pH in the optimum range. More than half of the total soils analyzed were deficient in phosphorus and could be expected to respond to additions of



Major agricultural areas of New York State

phosphorus. About a quarter of the samples were high in phosphorus. On the other hand, slightly more than one-quarter of the samples were low in potassium and about the same percentage were high in potassium. Although these figures are useful, they show nothing about the comparative fertility status of various regions of the State or the influence of the cropping system and concurrent practices on the fertility status of the soils.

To facilitate comparisons, the State was separated into what are called *geographic farming regions.* These regions are shown in the figure above; the regions follow county boundaries, and the counties in each region are shown. In the tables and discussion that follow, the regions will be referred to by the numbers indicated on the map. Finally, the results of soil tests were separated on the basis of cropping systems within the various regions, to permit comparison of the fertility status of cropping systems from one region to another.

Fertility Status of Different Geographic Farming Regions

The lime status of soils in the different geographic regions is shown in table 1. The areas tend to fall into 3 groups, with the soils found in regions 3, 6, and 8 having the greatest number of samples low in pH (below 6.0) and only a few above pH 6.5. The low pH found in region 8 (Long Island) is undoubtedly influenced by the fact that potatoes are the most important crop and a low pH is desirable for disease control. Regions 3 and 6, comprised of Oswego County and the Southern Tier, have soils derived largely from highly acid sandstones and shales. Only the additions of limestone on these soils can correct soil acidity and only a small percentage of the samples analyzed had been adequately limed. Samples from regions 1, 2, 4, and 7 were intermediate in lime status. In these areas, about 40 percent of the samples were low in pH and about 25 percent were high in pH. Some of the soils in these areas are high in limestone and need little or no additional lime; others are strongly acid and require liming. Most of the soils of the Hudson River Valley are derived from acid materials (region 7) but a substantially higher percentage are above pH 6 than in the Southern Tier, indicating that more lime has been applied. In regions 1, 2, and 4, the higher percentage of samples above pH 6 is probably a reflection of more soils derived from limestone materials than in area 6, for example. Region 5, which comprises the limestone belt of New York State, has only about 25 percent of the samples below pH 6 and more than 40 percent above 6.5. Unquestionably this is because most of these soils were derived from limestone materials and have a high native soil pH.

The wide ranges in phosphorus fertility status of soils in the different regions is shown in table 2. In region 8, which grows primarily vegetables, nearly four-fifths of the samples were high in phosphorus, although three-fourths of all the samples from regions 2 and 4 were low in phosphorus. Soils of the Limestone Belt and the Hudson River Valley areas were intermediate in phosphorus level, with about 40 percent of the samples low in phosphorus and about 33 percent high in phosphorus. Because the phosphorus levels found are primarily the

Table 1. Soil pH levels found in different geographic farming regions

Area	Number of Samples	Percentage of samples below pH 6.0	Percentage of samples above pH 6.5
1	2,448	36.3	28.4
2	1,120	39.2	28.4
3	569	54.3	14.1
4	2,922	44.0	25.4
5	17,885	27.3	43.0
6	20,088	55.1	15.4
7	7,717	38.2	26.3
8	128	59.4	15.6

Table 2. Soil phosphorus levels found in different geographic farming regions

Area	Number of samples	Percentage of samples low in phosphorus	Percentage of samples high in phosphorus
1	2,443	60.7	18.1
2	1,120	72.8	14.3
3	569	51.8	19.7
4	2,922	77.5	12.2
5	17,877	46.7	30.7
6	20,087	56.3	24.5
7	7,709	40.9	36.8
8	128	11.7	79.0

result of past treatment, it seems safe to conclude that farmers in regions 1, 2, and 4 have used less phosphate fertilizers than those in other regions. The Southern Tier region soils were somewhat higher in phosphorus than soils of regions 1, 2, and 4, but were still lower than soils of the Limestone Belt and the Hudson River Valley. With from 40 to 77 percent of the upstate soils low in phosphorus, there is continuing need for adequate phosphorus fertilization.

Except for region 8, the variation in soil potassium levels from region to region was not great (table 3). In region 8 the heavy fertilization of vegetables, particularly potatoes, shows nearly three-fifths of the samples high in potassium. Little difference was found amoung other areas, indicating that insufficient fertilizer potassium had been added to alter materially the levels of available soil potassium. Because only readily available potassium was measured, these figures give no indication of differences in potassium-supplying power of soils found in the different regions. Soils from the Limestone Belt have been found to have a high potassium-supplying power while those of the Hudson River Valley have a low potassium-supplying power. Soils of the Southern Tier have an intermediate potassium-supplying power. Both supplying power and the level of readily available potassium influence the need for fertilizer.

Table 3. Soil potassium levels found in different geographic farming regions

Area	Number of samples	Percentage of samples low in potassium	Percentage of samples high in potassium
1	2,443	40.8	18.7
2	1,120	27.6	26.7
3	569	26.7	30.6
4	2,922	37.0	21.6
5	17,876	31.0	26.6
6	20,078	24.1	32.6
7	7,709	29.1	32.9
8	128	16.4	58.6

Fertility Status of Different Cropping Systems in Different Geographic Farming Regions

Soil pH levels found with different cropping systems in the various geographic farming regions are shown in table 4. Variations in soil pH from region to region are apparent, as was shown previously in table 1. There was little effect, however, of the kind of cropping system upon the pH of the soil. The one exception to this appeared to be permanent pasture, where a somewhat higher percentage of the soils were below pH 6 than were the dairy or cash crops soils in some areas. These results indicate that regardless of the cropping system the same liming program was being followed, with the possible exception that permanent pasture fares less well than regularly cropped soils in areas where lime is needed.

Soil phosphorus levels varied widely from region to region and among cropping systems within regions as shown in table 5. Considering dairy farms only, nearly twice as many samples were low in phosphorus in regions 2 and 4 as in region 7. Region 7 yielded about 5 times as many samples high in phosphorus as region 4. The phosphorus levels found on dairy farms in regions 5 and 6 were similar, indicating that the Southern Tier and the Limestone Belt dairy

Table 4. Soil pH levels found with different cropping systems in geographic farming regions

Area	Number of Samples	Percentage of samples below pH 6.0	Percentage of samples above pH 6.5
		Dairy farms	
1	1,324	31.4	31.4
2	550	32.4	32.9
3	293	52.5	16.1
4	1,612	40.6	29.0
5	8,539	26.9	42.4
6	10,879	52.0	16.4
7	4,278	34.9	27.1
		Cash crops (wheat, beans)	
5	2,328	24.8	49.0
6	548	49.0	20.2
7	90	37.9	21.1
		Permanent pasture	
1	58	44.9	29.3
4	199	61.4	16.1
5	935	24.2	47.7
6	1,031	61.7	10.6
7	518	49.9	21.2
		Vegetable crops	
5	772	28.9	38.9
6	573	65.9	15.6
7	91	56.1	20.9

Table 5. Soil phosphorus levels found with different cropping systems in geographic farming regions

Area	Number of samples	Percentage of samples low in phosphorus	Percentage of samples high in phosphorus
		Dairy farms	
1	1,320	59.5	16.2
2	550	74.4	12.2
3	293	47.4	22.4
4	1,612	76.8	7.1
5	8,538	50.8	16.2
6	10,877	56.2	22.7
7	4,273	41.5	35.6
		Cash crops (wheat, beans)	
5	2,328	35.3	39.6
6	548	36.5	37.9
7	90	32.2	45.5
		Permanent pasture	
1	57	75.4	8.8
4	199	87.5	4.0
5	935	57.3	25.2
6	1,031	68.7	18.6
7	517	47.6	28.0
		Vegetable crops	
5	772	19.4	58.8
6	573	21.1	63.2
7	91	15.4	71.5

farmers apparently were using much the same fertilizer practices. The cash crop farms had a phosphorus level that was fairly consistent from region to region and they also maintained a higher level of fertility than the dairy farms in the same region. Likewise vegetable crops had uniform phosphorus throughout the various regions and had a fertility level even higher than that of the cash crop soils. Although the largest percentage of samples in the low phosphorus range occurred on soils in permanent pasture, there was considerable variation, and permanent-pasture samples from region 7 had a higher phosphorus fertility status than those from dairy farms in most regions.

Soil potassium levels of different cropping systems in the various geographic farming regions are given in table 6. There was some variation in potassium fertility status within a given cropping system from region to region, but the differences were not so great as the differences found in soil pH and phosphorus levels. The soil potassium level varied more among cropping systems within a single region than it did among regions. The differences in soil potassium levels among cropping systems may result from the level of potassium fertilizer applied to a particular crop, from the yield being obtained from a particular crop, or from a combination of both. High yields remove greater quantities of potassium than do lower yields, which may account for the fact that fewer

Table 6. Soil potassium levels found with different cropping systems in geographic farming regions

Area	Number of samples	Percentage of samples low in potassium	Percentage of samples high in potassium
		Dairy farms	
1	1,320	44.7	15.0
2	550	31.7	21.2
3	293	30.0	30.1
4	1,612	37.8	21.2
5	8,538	33.3	22.5
6	10,869	25.6	29.5
7	4,273	30.2	29.3
		Cash crops (wheat, beans)	
5	2,328	27.4	26.3
6	548	13.7	40.4
7	90	28.9	37.8
		Permanent pasture	
1	57	28.1	19.3
4	199	34.6	24.6
5	935	26.0	37.7
6	1,031	19.4	37.8
7	517	25.8	41.2
		Vegetable crops	
5	772	20.6	37.7
6	572	11.8	65.5
7	91	12.1	68.2

permanent pasture samples were low in potassium and more were high in potassium than were regular dairy farm soils in rotation. It seems reasonable to suppose that less total crop is removed from the permanent pasture than from the soils in field crops and, therefore, the amount of potassium removed is less. The generally higher soil potassium levels found with cash crops, and particularly vegetable crops, as compared with dairy farm crops, are undoubtedly the result of heavier use of potassium fertilizers. The cash crops and vegetable crops undoubtedly remove as much potassium as the dairy-farm crops; therefore these differences must result from heavier fertilization.

Organic-matter levels found in soils with different cropping systems in the various regions are given in table 7. Wide variations from region to region were found within the same cropping system. Organic-matter content of soils from regions 1, 2, 3, and 4, which comprise northern New York and the Mohawk River Valley, were substantially higher than from dairy farms in other areas. This is to be expected, because the average temperature is cooler and the growing season shorter in these areas than in other regions of the state, and the soils are probably in sod crops for a greater percentage of the time. All of these factors lead to the accumulation of organic matter and the slower decomposition of soil organic matter. Regions 5 and 7 which have the highest

Table 7. Soil organic matter levels found with different cropping systems in major farming regions

Area	Number of samples	Percentage of samples 0 to 3 percent O.M.	Percentage of samples 3 to 5 percent O.M.	Percentage of samples above 5 percent O.M.
		Dairy farm rotations		
1	1,324	1.7	34.3	63.9
2	550	1.8	46.4	51.8
3	293	2.3	44.0	53.6
4	1,612	4.0	42.9	53.2
5	8,535	19.8	60.0	20.3
6	10,879	5.8	52.8	41.6
7	4,275	12.4	65.3	22.3
		Cash crops (wheat, beans)		
5	2,324	27.7	58.6	13.5
6	548	16.5	67.1	16.1
7	90	11.0	63.3	25.6
		Permanent pasture		
1	58	5.1	27.5	67.2
4	199	2.0	43.8	54.3
5	934	14.7	47.2	38.0
6	1,031	4.3	41.6	54.2
7	518	11.4	53.7	34.9
		Vegetable crops		
5	772	29.5	59.4	11.3
6	574	19.8	62.6	17.6
7	90	40.0	39.9	20.0

average temperatures, the longest growing season, and the most intensive cropping, also have soils with substantially lower organic-matter content.

Organic-matter content of the soils in permanent pasture was generally higher than for any other cropping system. Because these soils are rarely if ever cultivated, organic matter tends to accumulate as a result of lower decomposition rates, and fairly large amounts of residues are left in the soil. On the other hand, soils in cash crops (particularly those in vegetable crops) were substantially lower in their organic-matter content than either the dairy farm soils or pastures. Intensive cultivation is conducive to a loss in organic matter. It appears that neither extreme depletion of organic matter nor organic-matter maintenance are serious problems for New York farmers.

What Farmers Are Doing — Fertilizer and Liming Practices

On the information sheet accompanying each soil sample, facts are routinely supplied about pertinent fertility practices being followed on the fields from which the samples were taken. Information on rate of liming and the number of years since the field was limed was analyzed to determine practices being

Table 8. Frequency of liming soils varying in lime status

Kinds of soils	Percentage of fields: Limed within 2 years of sampling	Not limed for 5 or more years
High-lime soils	41.1	34.1
Low-lime soils	49.4	27.7
Acid soils	43.4	29.1

followed by farmers of the State. From many of the samples received it was possible to separate those soils that were derived from parent materials high in lime, low in lime, and acidic, to compare liming practices. Table 8 shows the percentage of limed fields that had received lime not more than 2 years before sampling and those that had not been limed for 5 years or more. Interestingly enough the frequency of liming was about the same whether the samples came from the high-lime, low-lime, or acid soils. Regardless of the kinds of soils, about 40 to 50 percent of the fields had been limed within 2 years of sampling and about 30 percent had not received lime within 5 years of sampling.

The rates of lime applied to the various groups of soils are shown in table 9. Again there was little difference in rates of application of lime on the different kinds of soils. Most of the lime was applied at the rate of 2 tons per acre or less, regardless of the origin of the soils. An insignificant number of fields received 4 tons per acre or more, regardless of kinds of soil.

These data point out an interesting and important point: there is little or no difference in liming programs from an area like the Limestone Belt, where the native soil pH is reasonably high, to one with the most acid soils. Farmers in the Limestone Belt are using a substantial amount of lime and are liming frequently. It is surprising that farmers on the acid soils are not liming more frequently and at higher rates than those on the limestone soils. These data indicate that appreciably more lime should be applied on the inherently acid soils of the State. It appears that the rate and frequency of lime applications

Table 9. Lime application on soils varying in lime status

Kinds of soils	Percentage of fields where: 2 T/A or less used	4 T/A or more used
High-lime soils	86.7	2.7
Low-lime soils	71.1	6.8
Acid soils	79.1	4.8

Table 10. Average fertilizer use by crops, 1957-58

Crop	Percentage of fields where no fertilizer was used
Corn	15
Oats	22
Wheat	16
All hay	85
Alfalfa hay	71
All pasture	88
Sweet corn	10
Tomatoes	12

are maintaining soil pH in both regions, but in the acid-soil region this rate is insufficient to raise the soil pH to the most desirable levels.

Fertilizer usage on various field crops has also been summarized from the information sheets. The results of these summaries, which indicate the percentage of fields receiving no fertilizer for the various crops, are shown in table 10. These averages, on a statewide basis, clearly indicate that a large percentage of New York farmers are not applying minimum amounts of commercial fertilizer at planting time or as a topdressing on hay crops.

Farmers have overlooked the importance of fertilizer on 15 percent of the fields where corn has been produced. On 22 percent of the fields growing oat crops, no fertilizer was used. Sixteen percent of the wheat fields received no fertilizer. A surprisingly high percentage of New York farmers indicated that no commercial fertilizer had been used as a topdressing on their hay meadows. These data indicate that 85 percent of all hay meadows were not topdressed with fertilizer. Even more striking is the fact that 71 percent of the alfalfa hay crops were not topdressed. In addition, 88 percent of the pastures received no fertilizer. Although the percentage of sweet corn and tomato fields receiving no fertilizer at planting time was small, it is amazing that any acreage of these crops with a high acre value received no fertilizer.

Farmers who overlook this important phase in crop production cannot hope to produce efficiently and remain in a highly competitive enterprise. Most New York soils tend to warm up slowly in the spring. Proper fertilization helps the plants attain a rapid early growth when most soil nutrients are less available than later in the season when the soil is warmer.

Summaries of field corn fertilization practices by regions are presented in tables 11, 12, and 13. As shown in table 11, the use of nitrogen on corn varies considerably among the major agricultural regions of New York State. The percentage of farms using no nitrogen fertilizer on corn ranges from 12 percent in region 5 to 33 in region 4. Table 11, which shows the percentage of corn fields that received less than 40 pounds of nitrogen, indicates that an extremely

Table 11. Nitrogen use on field corn

Region	Percentage of fields where:	
	No nitrogen fertilizer used	Less than 40 pounds nitrogen used
1	28	82
2	28	90
3	15	81
4	33	90
5	12	78
6	15	76
7	17	75

high percentage of New York farmers are using less than 40 pounds of nitrogen on their corn crop. In all 7 regions, 75 percent or more were using minimum amounts or no nitrogen at all. Apparently, most farmers are using less than the generally recommended 40 pounds of nitrogen per acre.

The use of phosphorus on field corn, by regions, is shown in table 12. Where no phosphorus fertilizer was used, the same comparative relationship among regions existed as that for nitrogen. However, most farmers represented by these summaries apply more phosphorus than nitrogen as a fertilizer for corn. But in no region were as many as 50 percent of the farmers applying 40 pounds of phosphorus per acre to corn.

Fertilization of corn with potassium closely parallels that with phosphorus (table 13): regions 2 and 4 contained the highest percentage of fields receiving less than 40 pounds of potash. It appears that only a small percentage of farmers are applying the 40 pounds of potash per acre that is found in the general fertilizer recommendations.

It is true that liberal amounts of manure are applied to most corn fields before planting. In addition, corn crops usually derive considerable benefit from fertilizer applied at and near planting time. It is important to re-empha-

Table 12. Phosphorus use on field corn

Region	Percentage of corn fields where:	
	No phosphorus fertilizer used	Less than 40 pounds phosphorus used
1	28	61
2	26	77
3	14	60
4	31	83
5	12	58
6	14	59
7	16	60

Table 13. Potassium use on field corn

Region	Percentage of corn fields where:	
	No potash fertilizer used	Less than 40 pounds potash used
1	28	62
2	28	84
3	15	62
4	32	92
5	12	61
6	15	65
7	17	64

size the fact that corn is a potentially high-yielding crop and has a high acre value. Plant nutrients must be supplied in the correct amounts and at the proper time to achieve profitable returns from each crop acre.

Fertilizer use on hay crops by region is presented in table 14. These data clearly indicate that hay meadows are being grossly overlooked in the farm fertility program. In regions 1, 2, 4, 5, and 6, approximately 90 percent of the hay fields receive no topdressing with commercial fertilizer of any kind. In regions 3 and 7, more than 75 percent of the fields received no fertilizer topdressing. It should be remembered that these data are not from selected samples but from all soil test information sheets submitted with soil samples during 1957 and 1958. This total represented almost 53,000 samples.

As mentioned previously in this publication, a high percentage of New York soils tested low in phosphorus; approximately one-third tested low in potassium. As crop acres are more intensively managed in the future, more potassium samples are likely to fall into the low category. A response to applied fertilizer can usually be expected when the soil sample indicates low test values. Legume stands must be furnished with adequate supplies of plant nutrients to attain top hay yields and length of stand. Too many legume stands run

Table 14. Fertilizer use on hay crops

Region	Percentage of fields where:	
	No phosphorus used	No potassium added
1	91	92
2	89	91
3	83	87
4	90	91
5	89	90
6	87	90
7	78	79

out before they should because of low or limited supplies of nutrients in the soil. A complete soil test is the best way to determine the amount of fertilizer to be applied as a topdressing.

It has been clearly demonstrated through economic studies that farmers using adequate amounts of fertilizer tend to have the higher labor incomes. An interesting item in these same studies is that hay crop yields often parallel the labor income obtained by farmers.

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